IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant : Nagendran A/L C. Nadarajah et al
Serial No. : 10/664,807
Filed : September 17, 2003
Title : METHOD AND MEANS OF REPAIRING A PIPE

Art Unit : Unknown
Examiner : Unknown

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

TRANSMITTAL OF PRIORITY DOCUMENTS UNDER 35 USC § 119

Applicants hereby confirm their claim of priority under 35 USC § 119 from Malaysia Application No. P1 20023462 filed September 17, 2002 and Malaysia Application No. P1 20032723 filed July 21, 2003. Certified copies of each application from which priority is claimed are submitted herewith.

Please apply any charges or credits to Deposit Account No. 06-1050.

Respectfully submitted,

Reg. No. 54,694

Date: 10-20-2003

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PATENT APPLICATION NO: PI 2002 3462

This is to certify that annexed hereto is a true copy from the records of the Registry of Trade Marks and Patents, Malaysia of the application as originally filed which is identified therein.

By authority of the
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ABDUL RAHMAN RAMLI
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3 October 2003

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CERTIFICATE OF FILING

APPLICANT	:	i) NAGENDRAN A/L C. NADARAJAH ii) RENATA ANITA DE RAJ
APPLICATION NO	:	PI 20023462
REQUEST RECEIVED ON	:	17/09/2002
FILING DATE	:	17/09/2002
AGENT'S/APPLICANT'S FILE REF.	:	PK/P911/CS/2002

Please find attached, a copy of the Request Form relating to the above application, with the filing date and application number marked thereon in accordance with Regulation 25(1).

Date : 01/10/2002

.....
(ROZILEE BIN ASID)
for Registrar of Patents

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FF 09

Pat nts Form No. 1 PATENTS ACT 1983 REQUEST FOR GRANT OF PATENT (Regulation 7(1)) To: The Registrar of Patents Patent Registration Office Kuala Lumpur Malaysia	**For Official Use** APPLICATION RECEIVED ON: ..... Fee received on: ..... Amount: ..... *Cheque / Postal Order / Money Order / Draft / Cash No.: .....
Please submit this Form in duplicate together with the prescribed fee.	Applicant's file reference: **PK/P911/CS/2002**

THE APPLICANT(S) REQUEST(S) THE GRANT OF A PATENT IN RESPECT OF THE FOLLOWING PARTICULARS:

TITLE OF INVENTION: **METHOD OF REPAIRING A PIPE**

II. APPLICANT(S) (the data concerning each applicant must appear in this box or, if the space is sufficient, in the space below)

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- Permanent residence or principal place of business:

AS ABOVE

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Additional Information (if any)

III. INVENTOR

Applicant is the inventor: Yes [X] No [ ]

If the applicant is not the inventor:

Name of the inventors:

Address of inventors:

A statement justifying the applicant's right to the patent accompanies this Form:

Yes [ ] No [X]

Additional Information (if any)

IV. AGENT OR REPRESENTATIVE:

Applicant has appointed a patent agent in accompanying Form No. 17.

Yes [X] No [ ]

Agent's Registration No: **PA 90/019**

Applicants have appointed **P. Kandiah** to be their common representative

IV. DIVISIONAL APPLICATION

This application is a divisional application Yes [ ] No [ ]

The benefit of the

Filing date [ ] Priority date [ ]

Of the initial application is claimed in as much as the subject matter of the present application is contained in the initial application identified below: -

Initial Application No:

Date of filing of initial application:

VI. DISCLOSURES TO BE DISREGARDED FOR PRIOR ART PURPOSES

Additional information is contained in supplemental box:

(a) Disclosure was due to acts of applicant or his predecessor in title

Date of disclosure: ☐

(b) Disclosure was due to abuse of rights of applicant or his predecessor in title

Date of disclosure: ☐

A statement specifying in more detail the facts concerning the disclosure accompanies this Form

Yes ☐ No ☐

Additional Information (if any)

VII. PRIORITY CLAIM (if any)

The priority of an earlier application is claimed as follows :

Country (if the earlier application is a regional or international application, indicate the office with which it is filed):

Filing Date:

Application No:

Symbol of the International Patent Classification:

If not yet allocated, please tick ☐

The priority of more than one earlier application is claimed:

Yes ☐ No ☐

The certified copy of the earlier application(s) accompanies this Form:

Yes ☐ No ☐

If No, it will be furnished by (if requested by Registrar)

Additional Information (if any) :

VIII. CHECK LIST

A. This application contains the following:

1.	Request	1	sheets
2.	Description	7	sheets
3.	claim	2	sheets
4.	abstract	1	sheets
5.	drawing	2	sheets
	Total	13	sheets

B. This Form, as filed, is accompanied by the items checked below:

a) signed Form No. 17 X

b) declaration that inventor does not wish to be named in the patent

c) statement justifying applicant's right to the patent

d) statement that certain disclosures be disregarded

e) priority document (certified copy of earlier application)

f) cash, cheque, ~~money order, banker's draft or postal order~~ for the payment of application fee X

g) other documents (specify)

IX. SIGNATURE: ..... 17th September 2002

P. Kandiah
**(~~Applicant~~/Agent) (Date)

If Agent, indicates Agent's Registration No: **PA 90/019**

For Official Use

1. Date application received:

2. Date of receipt of correction, later filed papers or drawings completing the application:

* Delete whichever does not apply.
** Type name under signature and delete whichever does not apply

20023462

METHOD OF REPAIRING A PIPE

FIELD OF INVENTION

The invention relates to a permanent method of repairing a pipe more particularly the invention relates to a method of repairing a damaged pipe without isolating the pipe or without stopping the flow of materials within the pipe.

BACKGROUND ART

When pipe repairs are to be carried out, three main repair scenarios are normally encountered. This will include pipe subject to external metal loss (caused by corrosion or mechanical damage), pipes subject to internal metal loss (caused by corrosion, erosion or erosion/corrosion) and piping components that are leaking. In addition to these main repair scenarios, the extent of the deterioration or damage (i.e. localized or extensive) will also be considered when choosing the repair methods and repair components.

Current repair methods may include clamps (localized repairs) and specialized connectors with sleeves (extensive repairs). It is equally possible to encircle the defective area with close fit metallic sleeves which are welded together. This, however, has to be seal welded on pressure containing applications to the pipe being repaired at the terminals and could cause weld induced damage or material property changes on the pipe to be repaired. In underwater conditions this may require specialist habitats to carry out hyperbaric welding. This can prove costly and can pose additional dangers associated with welding on live pipelines.

The external pipe surface condition essentially dictates the type of repair to be carried out. If the external surface is damaged to the extent that an elastomeric seal cannot provide sufficient sealing forces in the immediate vicinity of the damage, or in the relatively unaffected areas adjacent to the major damage (these areas being used to effect the sealing forces of 'stand'-off repair clamps), the external pipe surface may need to be re-installed using some form of filler material. Developments using epoxy-filled steel sleeves have been shown to accommodate such areas of extensive damage

and have applications for a whole range of defects including corrosion, non-propagating cracks, dents or gouges in both axial and circumferential orientation, and girth weld associated anomalies. The epoxy-filled sleeve repair technique is typically recommended on areas operating below 100barg with temperatures not exceeding 100°C. It is assumed that epoxy filled sleeves can be used for leak containment. However in various tests conducted it was found that the sleeves were only able to contain leaks below 40barg. Additional tests were conducted to determine if pumping epoxy and allowing it to cure under pressure i.e. in equilibrium pressure (to that within the pipe) would produce better results. The tests prove that higher pressures are obtained but in practical terms this will involve de-rating the pipe or suspending production and could prove costly for operators. There is a need therefore to develop a method where the pipes can be repaired without de-rating the pipe or suspending the throughput of the pipe.

The prior art method is expensive in that heavy duty connectors dimensioned to fit the damaged pipes, need to be provided. Such connectors are expensive and take substantial man-hours to design, manufacture and assemble. The prior art composite fibre wraps does give way when the axial pressure exceeds 40barg or when used in isolation are considered temporary repairs.

SUMMARY OF INVENTION

The invention discloses a permanent method of repairing or reinforcing a weakened area in a pipeline section. The method includes removing rust, old coating and other unwanted surface blemishes by grit blasting. Then the leaking, damaged or weakened surface are wrapped with at least one layer of reinforced composite wrap material such as Syntho-Glass®. The composite wrap is left to cure. After that, two half oversized steel sleeves are installed over the pipe section and bolted together. The terminal annulus ends of sleeves are sealed either using fast curing resins or elastomeric material which are compressed to form a hermetic seal after sealing the annulus ends to form an annular chamber. Non gaseous matter is removed by flushing with fresh water and followed by flushing with inert gas or atmospheric air. Load bearing epoxy is then introduced into annular chamber. Types of load bearing epoxy

used are CCS Epoxy Grout. Finally the epoxy is allowed to cure. The above invention is used for pipelines submerged in water or sea. Alternatively the same method can be done for pipelines on land except the procedures are modified where by the two half oversized steel sleeves can be welded together and the flushing with fresh water will no longer be required. The unwanted matter can be flushed out using compressed air or inert gas.

DETAIL DESCRIPTION

The invention will be described in reference to a preferred embodiment of the invention with reference to the following diagrams:

Figure 1 shows a leaking, damaged or weakened surface area and the area beyond the leaking, damaged or weakened surface portion of pipeline is to be grit blasted.
Figure 2 shows a leaking, damaged or weakened surface area wrapped with fibre reinforced wrap.
Figure 3 shows an enclosing the surface area with two half oversized steel sleeves with inlet and outlet port. (Details of bolts and nuts or welds not shown).

The surface of a damaged/deteriorated pipe (10) is prepared first by grit blasting to remove rust and remnants of old coating. Grit blasting is known as one of the abrasive blasting. The blasting of the pipe (10) is carried out by sweep blasting using a fine abrasive not containing iron (e.g. garnet, aluminum oxide), glass pearls or stainless steel shot. Maximum speed and most effective cleaning are obtained by systematic blasting. Work is blocked out in 30cm squares and each square blasted evenly until complete. A minimum of 25mm into any adjacent coated area continued by blasting and the edges are feathered.

Then the thinned down, leaking or affected area is wrapped around with a fibre reinforced composite wrap (12) capable of curing under water and withholding pressure. Example of a wrap is Syntho-Glass® fiberglass cloth marketed by Neptune Research Inc. Syntho-Glass® is a fiberglass cloth pre-impregnated with a resin that can be activated by salt or fresh water. It is packaged in a hermetically sealed foil

pouch, it is ready to use and does not require any measuring or mixing. It has an initial settling time of only 30 minutes (24^0C). The number of wraps depends upon the operating pressure desired; the greater the pressure the more wraps. Once the wrap is cured, it is preferably control blasted to create an anchor pattern for the epoxy to be subsequently injected.

Two half oversized matingly engage able steel sleeves are then installed covering and extended to beyond the deteriorated pipe part of a pipe. The extension of the sleeves beyond the deteriorated part of the pipe is to cater for axial loads of the medium transported within the pipe. The ends of the sleeves are capped. The sleeves are welded or bolted together around and beyond the damaged/deteriorated or corroded area. The sleeves are with inlet (16) and outlet (18) port at the ends. The sleeves are dimensioned to allow an annular chamber (20) between the original pipe and the sleeves. Upon installation of the sleeves the ends are capped using either fast curing resins or elastomeric seals which are compressed when the sleeves are bolted or welded together or secured by other known means in the art. Examples of fast curing resins are CCS Underwater putty and Devcon Underwater putty. The annulus gap typically will range from 12.70mm to perhaps maximum of 76.20mm and will be dependent upon surface condition of the effected area i.e. dents, weld protrusions, out of dimension pipe etc. In addition the CCS Epoxy Grout can be formulated with additives or aggregates to either insulate the pipe (reduce thermal shock especially at the splash zone) or to reduce shrinkage of the epoxy.

All ambient water present in the annular chamber (20) should be discharged by means of the application of compressed air or other inert gas with a pressure not exceeding 9.7 bar (140psi) entering through the inlet port (16) and allowing discharge through the outlet port (18). The maximum pressures shown are for indicative purposes only and are dependent upon the capacity of the end seals.

Upon removal of all ambient water from the annular chamber (20) by means of compressed air or inert gas, the annular chamber (20) is flushed with fresh water. The fresh water is injected from the inlet port (16) and allowed to exit at the outlet

port (18). The fresh water is pumped at a pressure not exceeding 9.7bar (140psi). The procedure is continued until complete discharge of all contaminants and ambient water such as seawater. Upon completion of the above, the fresh water is discharged by means of introduction of inert gas. This procedure is continued until all moisture is discharged from the annular chamber (20). The pressure in the annular chamber (20) during the injection of the inert gas shall not exceed 9.7 bar (140psi).

Finally a load bearing epoxy capable of curing under water is then injected into annular chamber (20) of the sleeves through the pre-installed inlet and outlet port (16, 18) of 12.77mm diameter is placed at the steel sleeve into special prepared holes. The maximum injection pressure shall not exceed 9.7bar (140psi).

Load bearing epoxy used in this present invention is an epoxy grout. Example of an epoxy grout available in market is CCS Epoxy Grout, Low Exotherm. It has low viscosity, designed for application with automatic meter, mix and dispense pressure injection equipment. The physical properties allow its use in applications requiring high load bearing strength and excellent adhesion under adverse application conditions. It has a long working life and low exotherm reaction (minimal heat generation during cure (that make it suitable for applications where a relatively large mass of adhesive is employed. The CCS Grout, Low Exotherm is unique in the high degree of chemical and radiation resistance attained by an ambient temperature curing epoxy adhesive. The injected epoxy is left to cure for at least 7 days. Another type of epoxy available in the market is Epoxy Plus but it is not suitable for use underwater and in tests conducted indicated lower shear capacity on applications which were submerged in salt water beyond 72 hours. The opposite was true for CCS Grout. The tests were conducted to reflect real life scenarios (adverse weather conditions, welding time etc) where it could take as long as 96 hours after grit blasting for the epoxy to be injected.

The epoxy completely integrates the sleeves (14) and the existing pipe (10) providing additional structural reinforcement. The sleeves (14) isolate the pipe thus preventing further external corrosion and being bonded to the pipe (10) further

strengthens the pipe. The fibre reinforced wrap (12) contains leaks within corroded area and in conjunction with the load bearing epoxy contains the hoop stresses experienced by the pipe. The axial loads are contained by making sleeves longer than the affected area. This required length is calculated by diameter of the area to be protected and shear strength of the epoxy itself by applying the below formulas:

$$\text{Top of Riser Repair Sleeve;} \quad \text{Length}_{top} = \frac{F \times FoS}{\pi (OD_p)\, \text{Epoxy}_{shear}}$$

$$\text{Bottom of Riser Repair Sleeve;} \quad \text{Length}_{bottom} = \frac{[F - (F_{connector} \times g]\ FoS}{(OD_p)\, \text{Epoxy}_{shear}}$$

Symbol:

FoS = Safety Factor

$F_{connector}$ = Connector axial load capacity

OD_p = Outside diameter of pipe

F = Axial load acting on the stiffener/sleeve (assume dry weight of sleeve + pressure end cap force)

Epoxy_{shear} = Shear strength of epoxy

g = Gravitional force = $9.81 ms^{-2}$

$\pi = 3.142$

This invention is developed to solve problems presented by the large, high temperature risers/pipes operating up to 100^0C, causing thermal shock at the splash zone, failure of the protective coating, and the resulting accelerated corrosion.

The purpose of the invention is to provide a cost effective technology to rehabilitate these pipelines/risers operating at high pressures without suspending production, and to solve the problems caused by the accelerated rates of corrosion.

The advantages of this invention are it does not require de-rating of pipeline or suspending production, it does not require expensive heavy duty connectors to take

the axial loads or to contain leaks via seals normally incorporated within the connectors, does not require welding on the pipe to be repaired and it overcomes the limitations of epoxy sleeves and fibre reinforced wraps used independently.

The above invention is used for pipelines submerged in water or sea. Alternatively the same method can be done for pipelines on land except the procedures are modified whereby the two half oversized steel sleeves can be welded together and the flushing with fresh water will no longer be required. The unwanted matter can be flushed out using compressed air or inert gas.

CLAIMS

1) A method of repairing a leaking, damaged or weakened area in a pipeline section characterized in that the method includes:

   a) removing rust, old coating and other unwanted surface blemishes on the leaking, damaged or weakened surface area and the surface beyond the leaking, damaged or weakened surface portion of the pipeline (10);

   b) wrapping the leaking, damaged or weakened surface portion of the pipeline referred in step (a) above by having at least one layer of reinforced composite wrap material (12);

   c) allowing the reinforced composite wrap material to cure (12);

   d) enclosing the total surface areas referred to in step (a) with at least two half oversized steel sleeves (14);

   e) sealing the terminal annulus ends of sleeves ;

   f) removing non-gaseous matter in the annular chamber (20) formed by sleeves (14), pipe and the seals formed in step (d);

   g) introducing a load bearing epoxy into the annular chamber (20);

   h) allowing the load bearing epoxy to cure.

2) A method of repairing a leaking, damaged or weakened area in pipeline (10) section as claimed in claim 1 wherein in step (a) the surface areas are grit blasted.

3) A method of repairing a leaking, damaged or weakened area in pipeline (10) section as claimed in claim 1 wherein the reinforced composite wrap material (12) consists of fiberglass cloth pre-impregnated with a resin that can be activated by salt or fresh water.

4) A method of repairing a leaking, damaged or weakened area in pipeline section as claimed in claim 1 wherein the reinforced composite wrap (12) is wrapped in a special manner of the external surface of the pipeline (10).

5) A method of repairing leaking, damaged or weakened area in pipeline section as claimed in claim 1 wherein the each of the half oversized steel (14) structure includes an inlet port (16) and outlet port (18) respectively.

6) A method of repairing leaking, damaged or weakened area in pipeline (10) section as claimed in claim 1 wherein the terminal annulus ends are sealed by either using a fast curing resin or elastomeric material which is compressed to form a hermetic seal.

7) A method of repairing leaking, damaged or weakened area in pipeline (10) section as claimed in claim 1 wherein in step (f) the non-gaseous matter includes water or sea water.

8) A method of repairing leaking, damaged or weakened area in pipeline as claimed in claim 1 wherein the non-gaseous matter is removed by flushing the non-gaseous matter with fresh water followed by flushing with inert gas or atmospheric air.

9) A method of repairing leaking, damaged or weakened area in pipeline (10) as claimed in claim 1 wherein the load bearing epoxy is an epoxy grout.

10) A method of repairing leaking, damaged or weakened area in pipeline (10) as claimed in claim1 wherein the load bearing epoxy is introduced into the annular chamber (20) and left to cure.

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METHOD OF REPAIRING A PIPE

ABSTRACT

The invention relates to a permanent method of repairing leaking, damaged or weakened pipe by grit blasting the pipe (10), followed by wrapping it with a fibre reinforced composite material (12), then installing two half oversized steel sleeves (14). After that the non-gaseous matter is removed by fresh water and compressed air or inert gas. An epoxy is finally injected into annular chamber (20) of the sleeves through pre-installed inlet port (16) and outlet port (18). The epoxy is then allowed to cure.

FIGURE 3

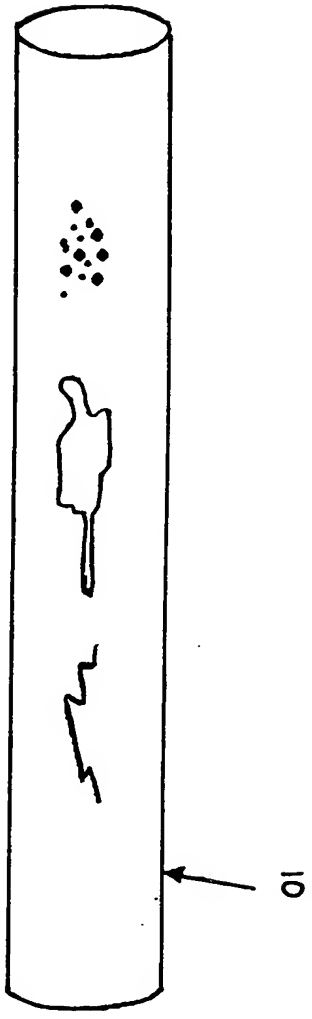

FIGURE 1

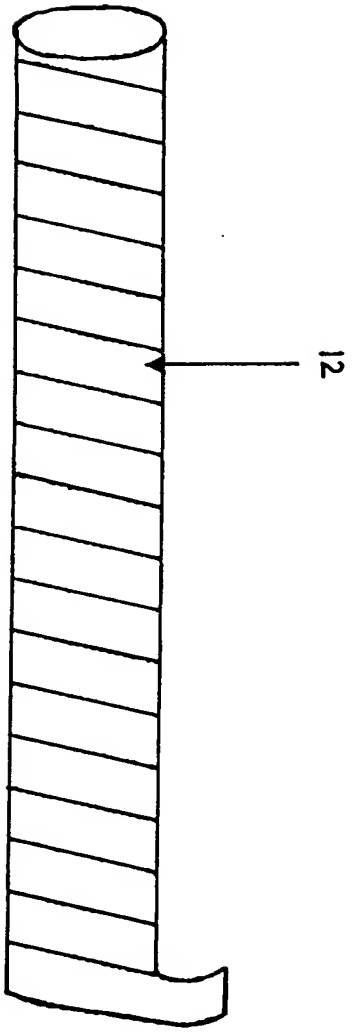

FIGURE 2

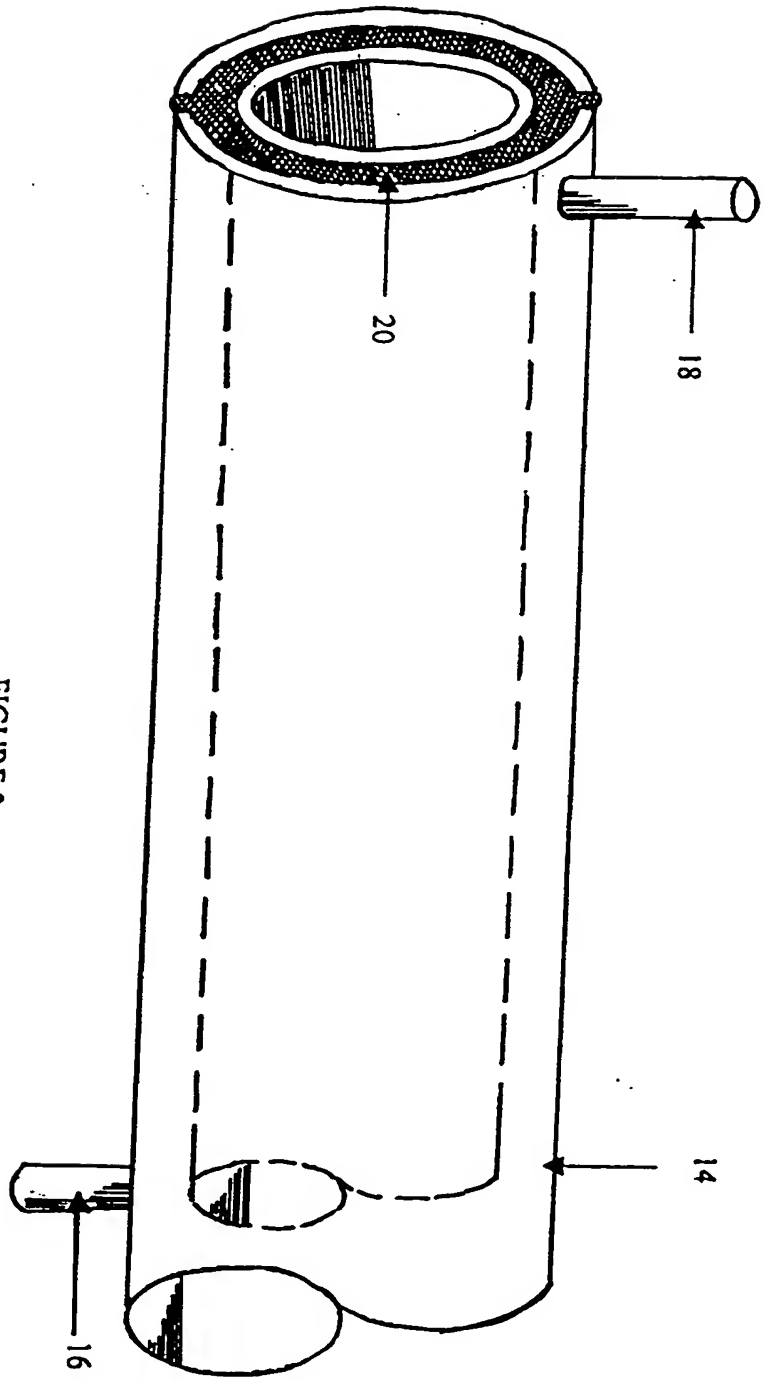

FIGURE 3